: Introduction

Nanomaterials are cornerstones of nanoscience and nanotechnology. Nanostructure science and technology is a broad and interdisciplinary area of research and development activity that has been growing explosively worldwide in the past few years. It has the potential for revolutionizing the ways in which materials and products are created and the range and nature of functionalities that can be accessed. It is already having a significant commercial impact, which will assuredly increase in the future.

What are nanomaterials?

Nanoscale materials are defined as a set of substances where at least one dimension is less than approximately 100 nanometers. A nanometer is one millionth of a millimeter - approximately 100,000 times smaller than the diameter of a human hair. Nanomaterials are of interest because at this scale unique optical, magnetic, electrical, and other properties emerge. These emergent properties have the potential for great impacts in electronics, medicine, and other fields .

Nanotechnologies involve designing and producing objects or structures at a very small scale, on the level of 100 nanometres (100 millionth of a millimetre) or less. Nanomaterials are one of the main products of

nanotechnologies – as nano-scale particles, tubes, rods, or fibres. Nanoparticles are normally defined as being smaller that 100 nanometres in at least one dimension.

As nanotechnology develops, nanomaterials are finding uses in healthcare, electronics, cosmetics, textiles, information technology and environmental protection.

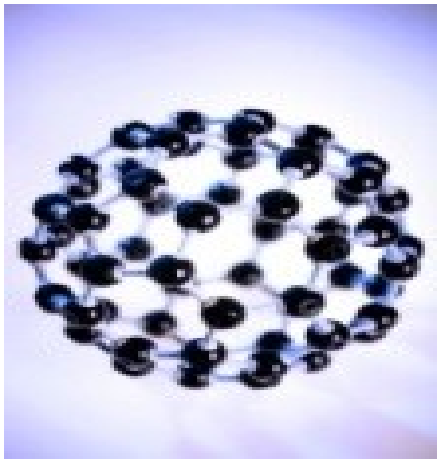
The properties of nanomaterials are not always well-characterised, and they call for risk assessment of possible exposures arising during their manufacture and use.

How can nanomaterials be characterised?

Descriptions of nanomaterials ought to include the average particle size, allowing for clumping and the size of the individual particles and a description of the particle number size distribution (range from the smallest to the largest particle present in the preparation).

Detailed assessments may include the following:

1. **Physical properties:**
   - Size, shape, specific surface area, and ratio of width and height
   - Whether they stick together
   - Number size distribution
   - How smooth or bumpy their surface is



- Structure, including crystal structure and any crystal defects
- How well they dissolve

2. Chemical properties:

- Molecular structure
- Composition, including purity, and known impurities or additives
- Whether it is held in a solid, liquid or gas
- Surface chemistry
- Attraction to water molecules or oils and fats

A range of techniques for tracking nanoparticles exist, and new ones are under development. Realistic ways of preparing nanomaterials for test of their possible effects on biological systems are also being developed.

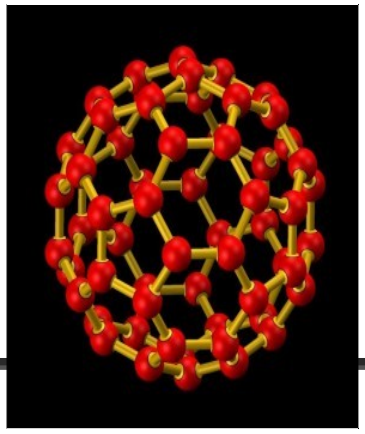
Types of Nanomaterials :

Nanomaterials have extremely small size which having at least one dimension 100 nm or less. Nanomaterials can be nanoscale in one dimension (eg. surface films), two dimensions (eg. strands or fibres), or three dimensions (eg. particles). They can exist in single, fused, aggregated or agglomerated forms with spherical, tubular, and irregular shapes.

Common types of nanomaterials include :

- **Fullerenes**

Fullerenes are actually grapheme sheets rolled in the form of spheres and are actually a class of allotropes of carbon. A main example of fullerene is carbon



nanotubes. They are known for their mechanical strength and their good electrical conductivity.

Fullerenes are mainly used in the medical field as they are known for binding certain types of antibiotics to the structure of resistant bacteria. They are also found to be resistant against melanoma, at type of cancer cell. All these are possible only because of the good physical and chemical properties of fullerenes. They are also known for their high resistance and superconductivity properties. Thus, they also find great applications as light-activated antimicrobial agents.

Fullerenes are obtained by inserting a large amount of current in between two very close graphite electrodes in an atmosphere that is inert in nature.

From the reaction a carbon plasma arc is obtained in between the electrodes, which then forms as a residue. This residue is then converted to obtain fullerenes.

- **Metal-based nanoparticles**

Inorganic nanomaterials, (e.g. quantum dots, nanowires and nanorods) because of their interesting optical and electrical properties, could be used in optoelectronics.

Furthermore, the optical and electronic properties of nanomaterials which depend on their size and shape can be tuned via synthetic techniques. There are the possibilities to use those materials in organic material based optoelectronic devices such as Organic solar cells, OLEDs etc. The operating

principles of such devices are governed by photoinduced processes like electron transfer and energy transfer. The performance of the devices depends on the efficiency of the photoinduced process responsible for their functioning. Therefore, better understanding of those photoinduced processes in organic/inorganic nanomaterial composite systems is necessary in order to use them in organic optoelectronic devices.

- **Two-dimensional nanostructures**

2D materials are crystalline materials consisting of a two-dimensional single layer of atoms. The most important representative graphene was discovered in 2004.

Box-shaped graphene (BSG) nanostructure is an example of 3D nanomaterial. BSG nanostructure has appeared after mechanical cleavage of pyrolytic graphite. This nanostructure is a multilayer system of parallel hollow nanochannels located along the surface and having quadrangular cross-section. The thickness of the channel walls is approximately equal to 1 nm. The typical width of channel facets makes about 25 nm.

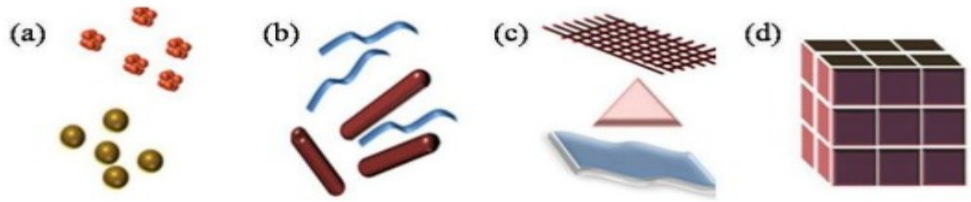
Thin films with thicknesses are considered nanostructures, but are sometimes not considered nanomaterials because they do not exist separately from the substrate.

- **Bulk nanostructured materials**

Some bulk materials contain features on the nanoscale, including nanocomposites, nanocrystalline materials, nanostructured films, nanotextured surfaces. Nanoporous materials and nanofoam are sometimes considered nanostructures but not nanomaterials because only the voids and not the materials themselves are nanoscale .

Nanomaterials have applications in the field of nano technology, and displays different physical chemical characteristics from normal chemicals (i.e., silver nano, carbon nanotube, fullerene, photocatalyst, carbon nano, silica(.

According to Siegel, Nanostructured materials are classified as Zero dimensional,
one dimensional, two dimensional, three dimensional nanostructures.



Classification of Nanomaterials (a) 0D spheres and clusters, (b) 1D nanofibers,
wires, and rods, (c) 2D films, plates, and networks, (d) 3D nanomaterials